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The Phoretic Behavior and Olfactory Preference of *Macrocheles muscaedomesticae* (Scopoli) (Acarina: Macrochelidae) in its Relationship with *Fannia canicularis* (L.) (Diptera: Muscidae)[1]

ERIN E. RILEY BORDEN

Department of Entomology, Washington State University, Pullman, Washington 99164-6432.

Abstract.—The phoretic behavior and olfactory preference of *Macrocheles muscaedomesticae* (Scopoli) (Acarina: Macrochelidae) were studied in regard to their relationship with *Fannia canicularis* (L.) (Diptera: Muscidae). The mites and fly larvae were located in the top 5 cm of poultry manure cones. An average of one female mite was found on each female *F. canicularis* collected in the field.

The olfactory preference of the mite was determined to be for the adult, followed by the egg, larva, and pupa of *F. canicularis,* respectively. Studies indicated that the mites have a negative effect on the oviposition and longevity of the flies.

Fannia canicularis (L.) (Diptera: Muscidae), the little house fly, is an important pest of humans and livestock. The fly is capable of carrying many viral and bacterial pathogens and therefore is also a public health concern (Axtell, 1985). It is a prime pest in poultry houses where the rapid accumulation of manure serves as an excellent breeding medium for the fly.

In San Diego County, California, *F. canicularis* is the major pest associated with poultry ranches. Large populations of flies cause severe annoyance to workers and fecal material produces unacceptable spots on eggs and equipment. However, the flies are most troublesome when they disperse to surrounding areas where they constitute a serious nuisance to the people in neighboring homes and businesses. This strains community relationships and sometimes leads to lawsuits. *Fannia canicularis* also spreads pathogens that cause poultry diseases; of particular importance is the virus that causes velogenic viscerotropic Newcastle disease (VVND), a serious problem in poultry (Axtell, 1985).

Macrocheles muscaedomesticae (Scopoli) (Acarina: Macrochelidae), a mite commonly found in manure, is an effective predator on the eggs and first instars of *F. canicularis* (Axtell, 1961; Pereira and de Castro, 1945, 1947; Steve, 1959; Wicht and Rodriguez, 1970; Willis and Axtell, 1968). In recent years studies have concentrated on using this mite, selected pesticides, and microbial agents in integrated pest management programs for muscid flies (Wicht and Rodriguez, 1970; Anderson, 1982; Krantz, 1982).

[1] Work done at San Diego State University, continued under project 0807 at the College of Agriculture and Home Economics, Washington State University, Pullman, Washington 99164-6432.

Behavioral studies (Axtell, 1964; Farish and Axtell, 1966, 1971; Kinn, 1966; Jail and Rodriguez, 1970) have detailed some of the predatory behavior of the mite on the house fly, and Jail and Rodriguez (1970) discovered that olfactory cues directed the mite to its host. It preferred adult house flies to eggs. The adult female of *M. muscaedomesticae,* in addition to being a predator, is also phoretic on adult *F. canicularis* (Steve, 1959; Singh et al., 1966; O'Donnell and Nelson, 1967; Wicht and Rodriguez, 1970; Axtell, 1981). It is unknown if this relationship is simply phoresy or if parasitism (feeding by the mites) is also involved.

The purposes of this study were to ascertain the location of *M. muscaedomesticae* and the immature stages of *F. canicularis* in poultry manure cones, to determine if *M. muscaedomesticae* is found on adult *F. canicularis* in the field, and to determine if there is a preference by *M. muscaedomesticae* for certain stages of *F. canicularis.* In addition, the relationship between adult female *M. muscaedomesticae* and adult *F. canicularis* was examined by studying oviposition and longevity of the flies.

Materials and Methods

Fly Population

Rearing.—*Fannia canicularis* (Laboratory stock, University of California, Riverside) were reared on spent (previously composted non-heat generating which is suitable for the low temperature tolerance of the little house fly) *Musca domestica* (L.) CMSA (Chemical Specialties Manufacturers Association) medium that was frozen to kill any remaining *M. domestica.* Four sleeve cages each containing ca. 100 adult flies were maintained throughout the study, and were provided with water and a powdered sugar–milk mixture (1:1). Fresh water and fresh protein mixture were provided every third day. Eggs were collected by placing a tablespoon of spent CSMA medium (which had been sewn pillow-like into a piece of muslin cloth) into the sleeve cage for 24 hr. Eggs could be removed from the pillows by a simple rinsing with distilled water.

Mite Population

Rearing.—The mites were collected from the surface layer of chicken manure from the Hiliker Poultry Ranch in Lakeside, California (San Diego County). The top 3–5 cm of a manure cone was collected and stored in waxed containers until the sample could be placed into a modified Berlese funnel (MacFadyen, 1953; Averbach and Crossley, 1960) to separate the mites.

Stock cultures were initiated by taking samples from jars below the Berlese funnels, chilling them (2–3 min), and sorting the *M. muscaedomesticae* from other arthropods. Female mites, easily recognized by their oval body and ventral plates (Wade and Rodriguez, 1961), were placed via a camel's hair brush into plastic containers (9 × 9 cm with a 4 × 4-cm screened hole in the lid) that contained moist spent CSMA medium. The mites were maintained in an incubator at 27 ± 1°C. Although relative humidity was not controlled, water was added every third day so that the medium remained slightly damp. Frozen fly eggs were added to the cultures every other day. Cultures remained in good condition for about 5 wk, until fungal growth developed in the medium and it had to be replaced.

Collection of Manure Samples

Collections of manure were made to determine where in the manure cone the *M. muscaedomesticae* and larvae of *F. canicularis* were located. Pie-tin (12.5 × 3.5-cm) sized samples were taken from the cone with a wooden spatula (10 × 6 cm). The samples were stored in wax containers with plastic wrap cover to prevent desiccation until analyzed. Each sample was divided into 5 parts of ca. 10 g each for analysis under a dissecting microscope. The samples were picked apart with a metal probe and visually scored for *M. muscaedomesticae* and *F. canicularis* larvae. Manure samples were taken at 5-cm, 10-cm, 15-cm, and 30-cm levels from the top of the manure cone. Samples were also taken from directly around the bottom of the cone and 5 cm out from the bottom of the cone in the dry, flat, dust area.

Olfactory Orientation Tests

Olfactory response tests were conducted to determine if *M. muscaedomesticae* preferred any one stage of the fly. These tests used *F. canicularis* and *M. muscaedomesticae* from the laboratory stock.

Apparatus.—The olfactory response of the mite was tested in a glass olfactometer (Fig. 1) consisting of four horizontal tubes each 1 cm diam and 6 cm long. A fifth vertical tube, which entered from above and was placed at the center of the preference tubes, was used to place the mites into the apparatus. Previous researchers employed a simple choice tube (Jail and Rodriguez, 1970) or an area type apparatus (Farish and Axtell, 1966). Neither of these designs was suitable for my investigations.

Preliminary bias tests.—Fifty-two mites were used for this experiment. The apparatus was rotated a quarter of a turn after each mite was tested to test for possible responses due to differences in lighting or for other directional responses due to unknown factors. The mites were introduced into the apparatus individually, and each mite was removed before the next was introduced. The procedure was modified from previous experiments where mites were tested in large groups (Farish and Axtell, 1966; Jail and Rodriguez, 1970). In these tests, mites were run separately to eliminate any possible following behavior. Each mite was taken from its culture with a fine camel's hair brush, placed into the center of the apparatus, and given 30 sec to make a choice. If no choice was made, the mites were removed and discarded. A choice was recorded when a mite crawled into one of the four arms a distance of at least 2 cm. The mite was then transferred to a new stock container. None were used repeatedly. Of the 50 mites tested, 12 went down arm 1, 12 down arm 2, 11 down arm 3, and 12 down arm 4. This indicated the apparatus was suitable for olfactory tests.

Olfactory tests.—This experiment was conducted to determine if any stage of the fly was preferred by the mite. Viable eggs, larvae, pupae, and adults of *F. canicularis* were used. One developmental stage of the fly was live mounted at the end of one of the tubes with wax. An egg was mounted in arm 1, a larva in arm 2, a pupa in arm 3, and an adult in arm 4. The mites were introduced one at a time and removed after making a choice. Again, the mites were given 30 sec to make a choice after which time they were removed. A choice was defined as the mite walking 2 cm into one of the arms. The apparatus was again rotated

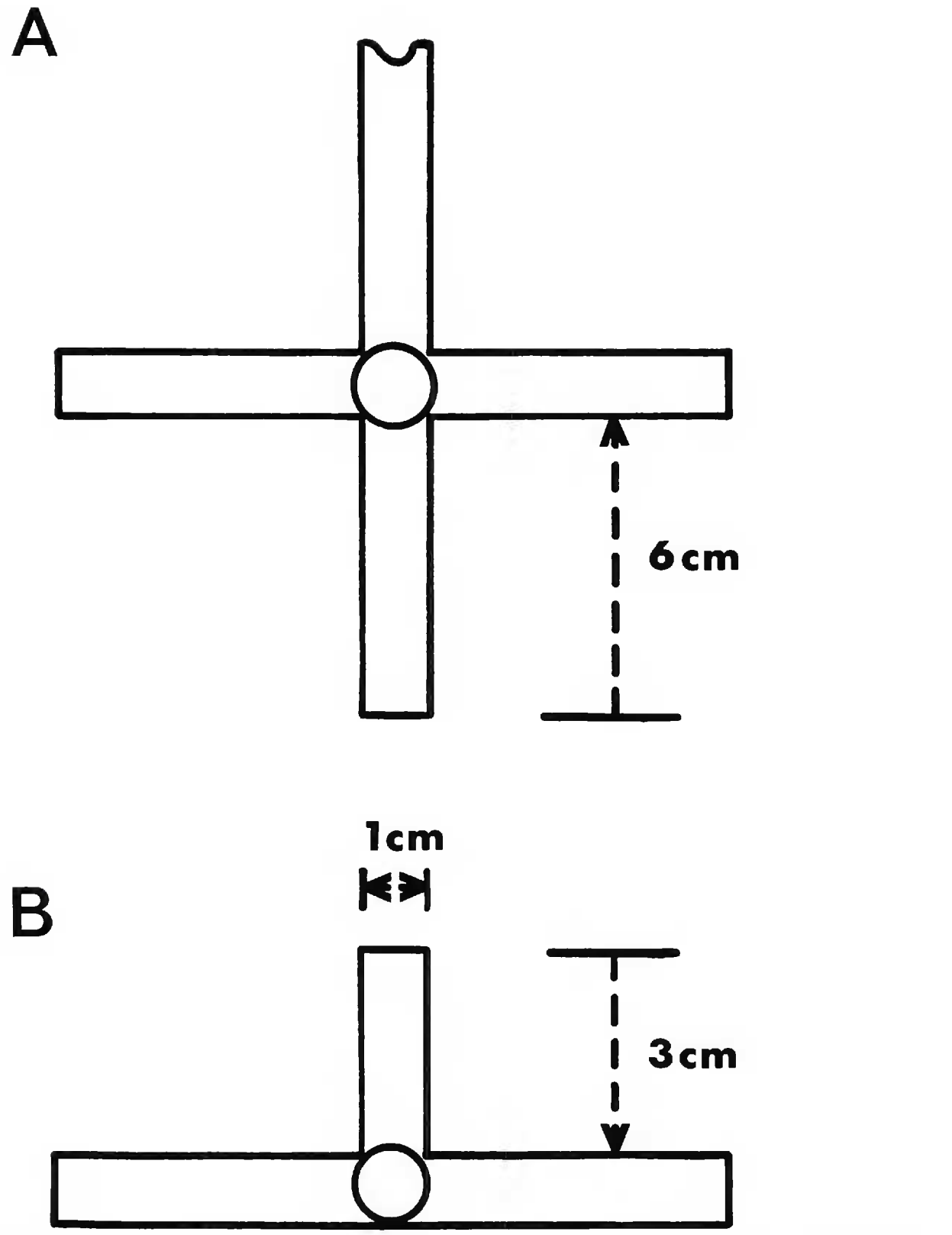

Figure 1. Apparatus used to test the olfactory preference of the mite. A = plan of the apparatus; B = elevation of apparatus.

after each trial to control for differences in room lighting or possible directional preference by the mites. A total of 200 mites were tested in four replicates consisting of 48, 52, 48, and 52 mites, respectively. After a replicate was completed, the fly stages were removed, and the apparatus was washed with 70% ethanol and rinsed with water. Fresh fly stages were then mounted in the apparatus for the next test.

Field Collection of Adult *Fannia canicularis*

Fannia canicularis were field collected to determine the average number of *M. muscaedomesticae* found on adult flies. The collection trap consisted of a cardboard, triangular trap with sides of 9.5 cm with a rectangular sticky board base

9.8 × 17 cm. Inside the trap a cotton wick hung above the sticky board. The wick was saturated with "Grandma's molasses"® obtained locally.

A fresh cotton wick with molasses was furnished every second week. The sticky boards were removed from the traps when they became covered with insects, or every 2 wk and were replaced with fresh boards. Boards were placed into plastic bags for transport to the laboratory for examination under a dissecting microscope. The number and sex of *F. canicularis* on the board were noted, along with the number of attached mites. The collection and examination of flies continued from 17 February through 27 April 1986.

Studies on the Phoretic Behavior of *Macrocheles muscaedomesticae*

Since previous experiments had suggested that the mite had a deleterious effect on the fly, I decided to investigate oviposition and longevity.

The normal, average number of eggs laid by *F. canicularis* was determined by placing 32, 7–8-day-old female flies (which had previously not oviposited) into individual vials. The flies were chilled for 5 min to facilitate handling. Each vial contained one muslin cloth egging pillow (2 × 2 cm) filled with previously thawed, spent CSMA fly medium. The flies were then held at 25°C for 24 hr. After 24 hr, the number of eggs present was determined.

A second test was performed in which one female mite per fly was added. Since only female mites are phoretic (Axtell,1964) they were the only sex used. Each mite was picked at random from a stock container with a fine brush and placed on an immobilized fly. After 24 hr, a count of fly eggs present was again made.

Longevity experiment.—These tests were conducted to determine if *M. muscaedomesticae* affected the life span of the fly. Fifty 3-day-old flies were placed into individual vials. Each fly had one female mite placed on it. A control group of 50 miteless flies was run simultaneously under the same conditions. The vials were held at 25°C, and no food was supplied during the experiment (Jail and Rodriguez, 1970). Longevity was recorded in days.

Results

Collections from Chicken Manure

Macrocheles muscaedomesticae was found together with *F. canicularis* larvae only in the top 5 cm of the manure cone (Fig. 2), although fly larvae continued to be present to at least a depth of 10 cm. None of the other sample sites yielded either flies or mites.

Olfactory test.—Two hundred mites were tested in replicates of 48, 52, 48, and 52 mites, respectively. Sixty chose the egg, 28 the larvae, 36 the pupa, and 70 the adult. The mite clearly showed a preference for the adult and egg (chi-square, 25.52 significant to 0.001).

Of the 109 adult *F. canicularis* collected, only 11% had mites and a maximum of one female mite per fly was found. In addition all mites were found on female flies, although both male and female flies were found in the traps.

Nine of the 32 flies tested without mites did not lay eggs, 22 of the flies with mites did not lay eggs (z-test, $z = 2.97$, significant at 0.05, two-tailed test) (Wonnacott and Wonnacott, 1985). Dissection revealed that all the flies that failed to oviposit had mature eggs in the ovaries. A comparison of the flies alone and the

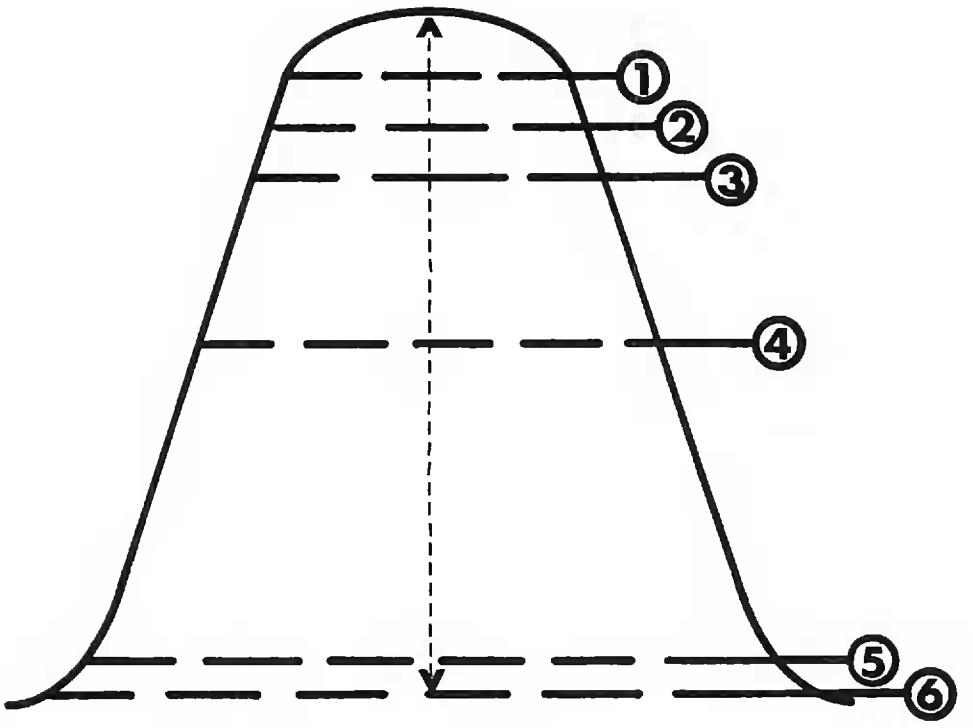

Figure 2. Collection sites in a typical chicken manure cone.

flies with mites using a completely randomized analysis of variance test resulted in an *F*-value of 7.71 which is significant at 0.01 (Wonnacott and Wonnacott, 1985). A comparison of the two groups of flies using the same statistical test, but excluding the flies that did not oviposit, results in an *F*-value of 4.12 which is significant at 0.10 level.

The average life span of flies without mites was 1.5 days while that of flies with mites was 1.3 days. This was not a significant difference.

Discussion

The mite showed a definite olfactory preference for the adult and egg stage of the fly, and the phoretic studies indicated that the mite has a negative effect on oviposition and perhaps to some extent longevity of the fly.

The locations of the mites and flies in the top 5 cm of the manure cones suggests the mite may be an important controlling agent of *F. canicularis* on poultry ranches in San Diego County. On poultry ranches where the flies are in high population a staggered removal of manure cones may facilitate maintaining a high predatory mite population. Also chemical spot treating the manure cones and avoiding the high mite areas may help decrease fly populations (Axtell, 1985).

The preference of the mite for the adult fly agrees with the results of a similar study on *M. domestica* (Jail and Rodriguez, 1970). Perhaps the phoretic attachment of the mite to the fly takes place when the manure is less attractive (e.g., dry) to the fly and losing its ability to support a high mite population. The mites would benefit by choosing an adult fly for transport to a new manure source, and hence, a food supply in the form of fly eggs.

A single mite on *F. canicularis* reduced longevity and oviposition, but there still is speculation whether there is actual feeding by the mite on the fly. Jail and Rodriguez (1970) attempted to show that the mite feeds on the fly by weighing the fly after infestation with mites. They found that flies lost weight compared to a control, and attributed this weight loss to the mites sucking haemolymph from the fly. Further studies investigating actual feeding on the flies should test the

longevity of the mites on flies compared to mites alone, and changes in the water content of the mites. The relatively high number of mite infested flies that did not lay eggs suggests that mites may reduce little house fly populations in this manner. However, since my tests lasted only 24 hr, the oviposition experiment must be carried out over the total life cycle of the fly to determine if the mite can reduce the fly population by completely inhibiting oviposition. However, since ammonia vapor from manure causes the mites to drop from the flies (Pereira and de Castro, 1947), this may not work.

These studies confirm the potential for the use of *M. muscaedomesticae* as a biological control agent of flies. They also show that *M. muscaedomesticae* has the potential to be an important part of integrated fly control of *F. canicularis* in San Diego County.

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